

# QB50

Welcome

Practical Aspects

Status of the project

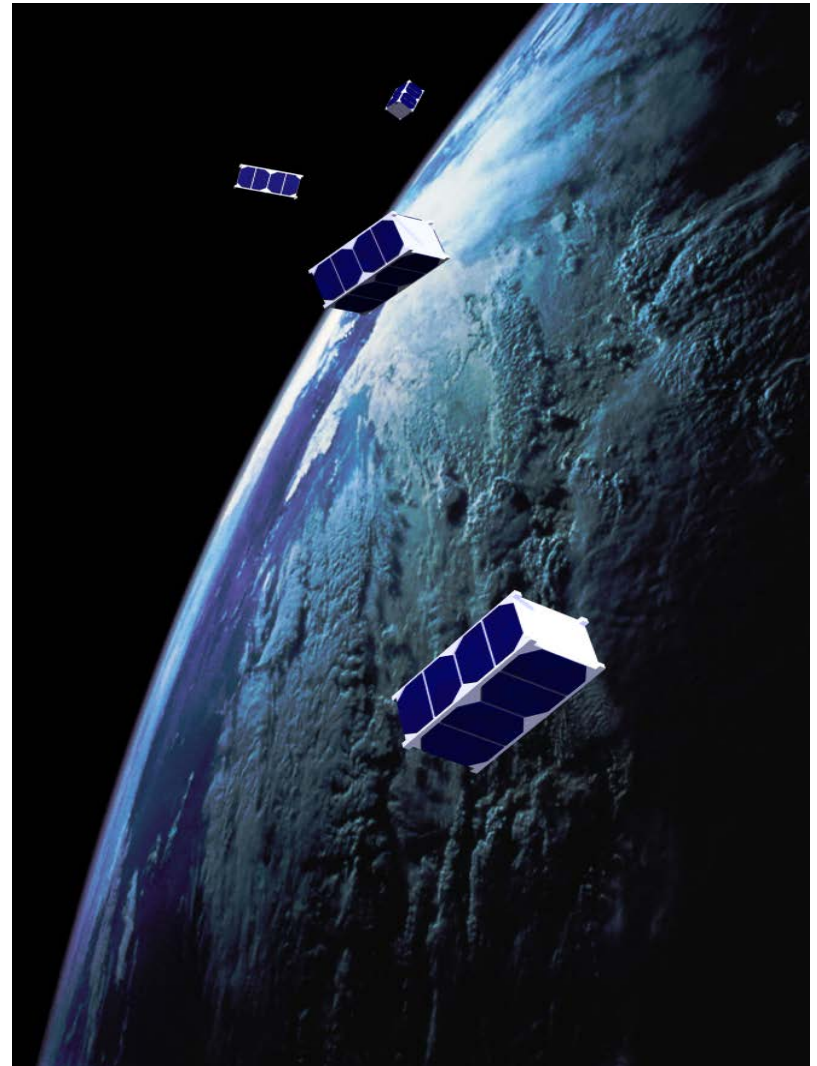
***J. Muylaert***

von Karman Institute for Fluid Dynamics  
Rhode-Saint-Genèse (Brussels)

**5th QB50 Workshop**

29 Jan 2013

Rhode-Saint-Genèse, Belgium



- First QB50 Workshop: Nov 2009
- Second QB50 Workshop: July 2011
- Third QB50 Workshop: 2 Feb 2012
  - Give info on the upcoming Call for Proposals
- Fourth QB50 Workshop: 12-13 June 2012
  - Face-to-face meetings with all participating CubeSat teams
- **Fifth QB50 Workshop: 29 Jan 2012**
  - **QB50 Requirements & Interface Control Docs**
  - **Procedures for the PDR**
- Sixth QB50 Workshop: 6 June 2012
  - right after the European CubeSat Symposium 3-5 June 2013
  - presenting detailed information on the Science Payload and CDR procedures



## 28 Jan 2013, Monday

- 10:30 – 15:30      Orbital Dynamics Working Group  
14:00 – 17:00      QB50 Ground Segment Meeting

## 29 Jan 2013, Tuesday

- 09:00 – 15:30      **5th QB50 Workshop**  
15:45 – 17:30      Splinter session for GAMA-NET (meeting at the Canteen)  
16:30 – 18:30      Lectures on CubeSat Technology and Application

## 30 Jan 2013, Wednesday

- 09:00 – 17:30      Lectures on CubeSat Technology and Application  
10:30 – 17:00      Ground Station Network and Frequency Allocation Working Group Meeting  
17:30 – 19:00      Reception

## 31 Jan 2013, Thursday

- 09:00 – 17:30      Lectures on CubeSat Technology and Application

## 1 Feb 2013, Friday

- 09:00 – 17:30      Lectures on CubeSat Technology and Application

*We are fully booked!*



**Chairperson: R. Reinhard**

08:30 Registration

09:00 Welcome and practical issues *J. Muylaert*

Status of QB50 Project

Contractual Agreement

09:40 European CubeSat Symposium 3-5 June 2013 *R. Reinhard / C. Asma*

**09:45 Coffee Break**

10:15 Mission Objectives *R. Reinhard / C. Asma*

Overall QB50 requirements *F. Singarayar*

Launch environment and loads *C. Bernal*

Deployment System Requirements

**12:00 Lunch**

**12:00** *Lunch*

13:30 Science payloads sets and requirements

*D. Kataria*

14:15 Mission Control Software

*M. Richard*

GAMA-Net introduction

*P. Rodrigues*

14:30 Coffee Break

15:00 PDR Procedures

*F. Singarayar*

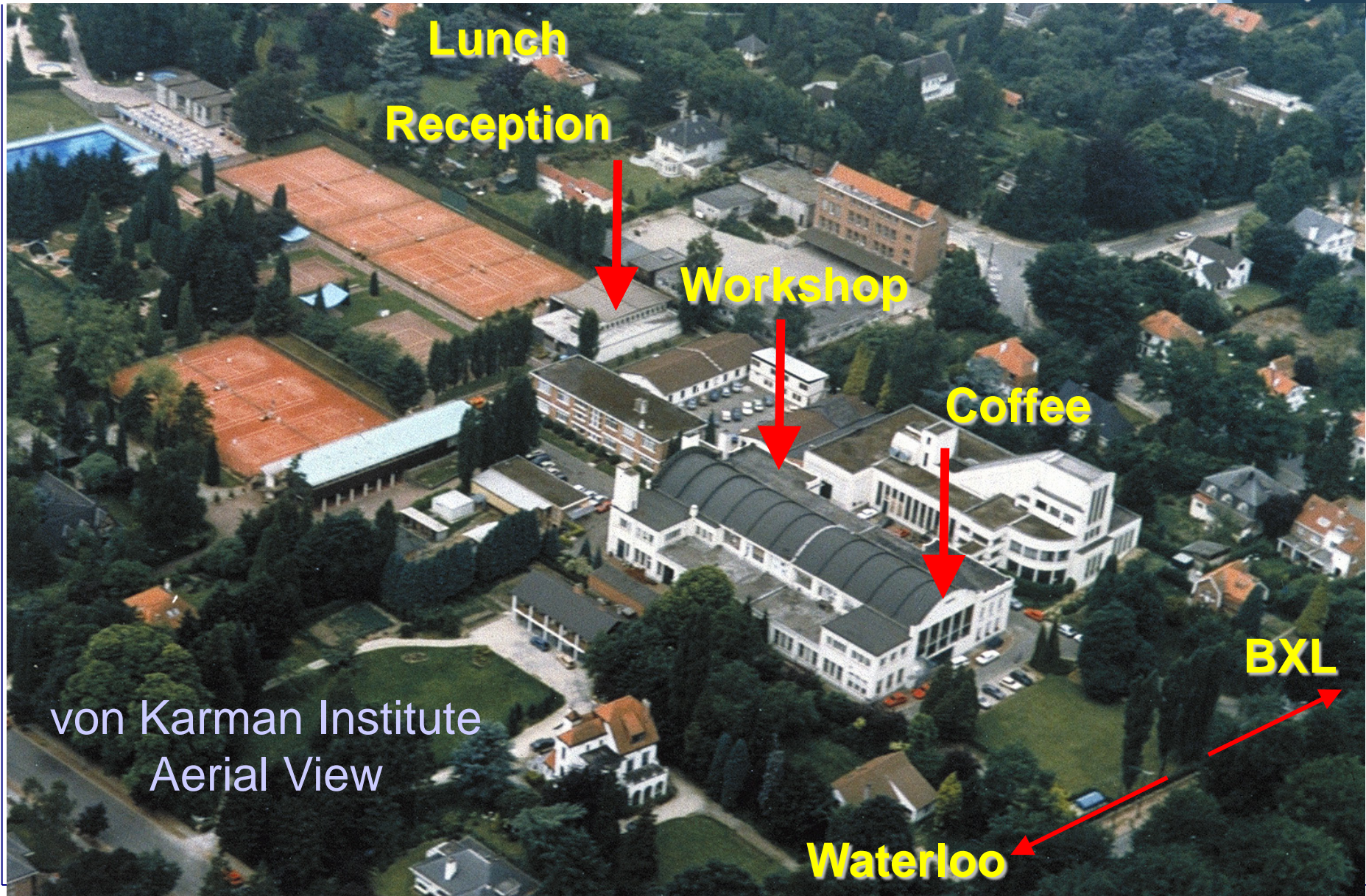
15:30 Closure

*J. Muylaert / R. Reinhard*

15:45 GAMA-Net splinter session (optional, meet at the canteen)



# Practical Aspects



von Karman Institute  
Aerial View



## ***WIRELESS INTERNET***

### ***WIFIGUEST***

*Userid:* CubeSat

*Password:* I<3CubeSats



## ***SMOKING?***

**No smoking** anywhere in non-open air workspaces (Belgian Law)

## ***OTHER QUESTIONS?***

The VKI Receptionist (taxi, directions, contacting people)

The VKI Secretariat (CubeSat Lectures registration)

Cem O. Asma (The Workshop Secretary)

# QB50 Team Members



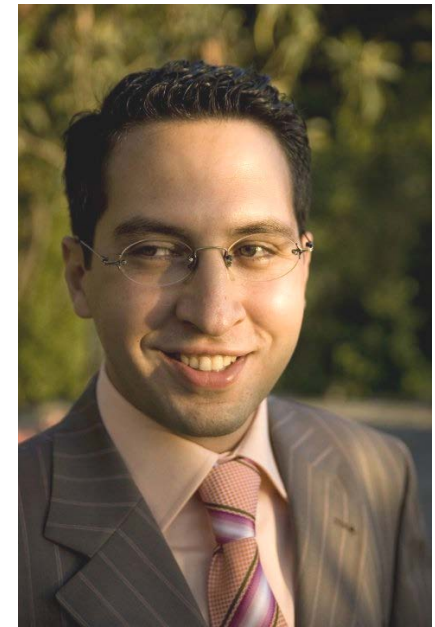
**Jan Thoemel**

*QB50 Project Manager*



**Fiona Singarayar**

*QB50 Systems Engineer*



**Cem O. Asma**

*QB50 Point of Contact*



# NEED ANY HELP ?



Can I HELP you ?

Je peux AIDER vous ?

Size nasıl YARDIM edebilirim ?

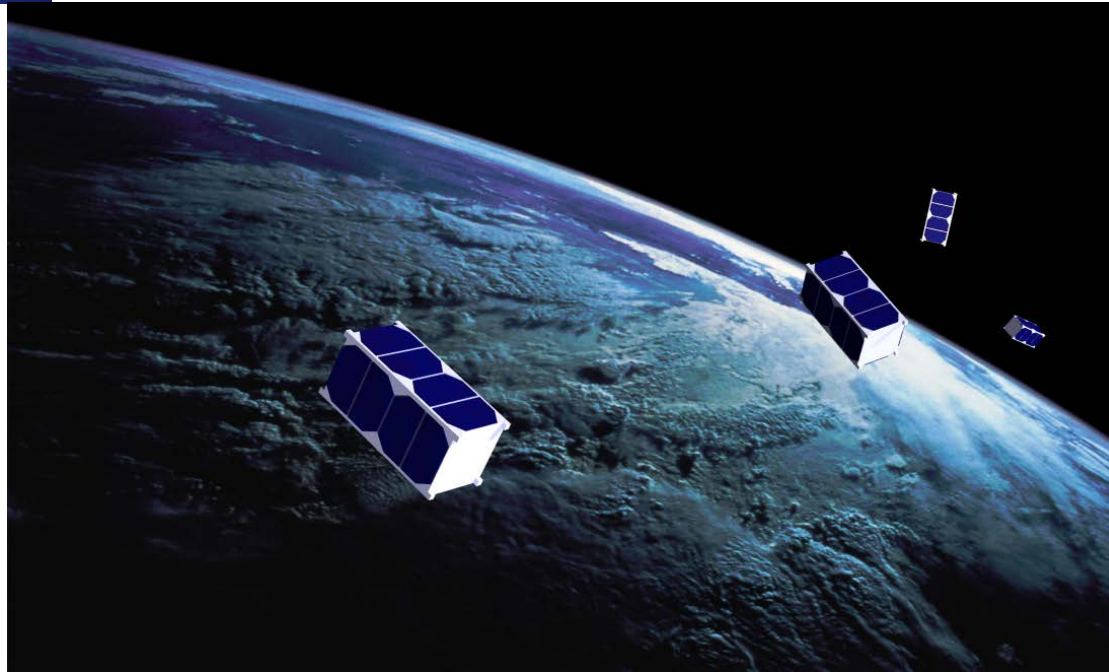
Posso AIUTARLA ?

Işıl Şakraker

VKI Staff



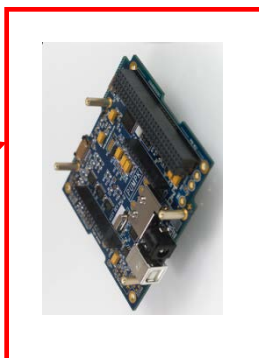
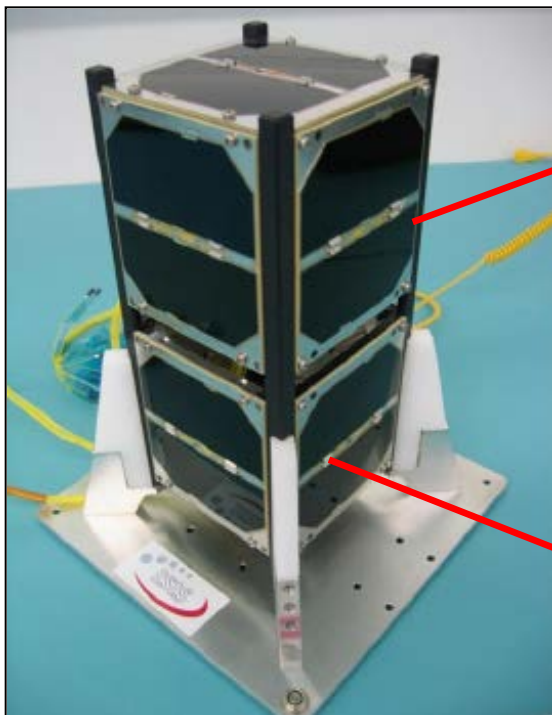
# QB50 - THE IDEA



- An international network of 50 CubeSats for multi-point, in-situ, long-duration measurements and in-orbit demonstration in the lower thermosphere
- A network of 50 CubeSats sequentially deployed
- Initial altitude: 350 km (circular orbit, high inclination)
- Downlink using the QB50 Network of Ground Stations

# QB50 - The CubeSat

**On a Double CubeSat (10 x 10 x 20 cm<sup>3</sup>):**

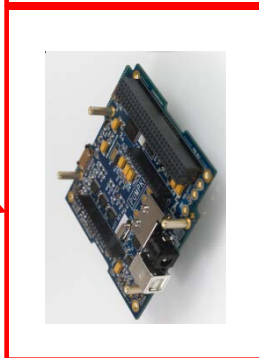


## **Science Unit:**

*Lower Thermosphere Measurements*

*Sensors designed by MSSL*

*Standard sensors for all CubeSats*



## **Functional Unit:**

*Power, CPU, Telecommunication*

*Optional Technology or Science Package*

*Universities are free to design the functional unit*

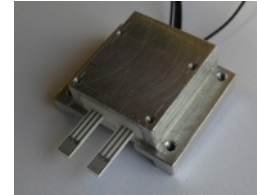


# Sensor Selection

## Set 1

- Ion-Neutral Mass Spectrometer (INMS)
- 2 corner cube laser retroreflectors (CCR)\*
- Thermistors/thermocouples/RTD (TH)

FIPEX sensor



## Set 2

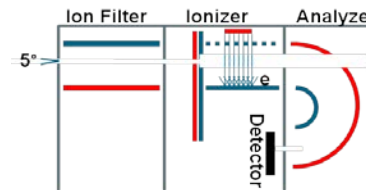
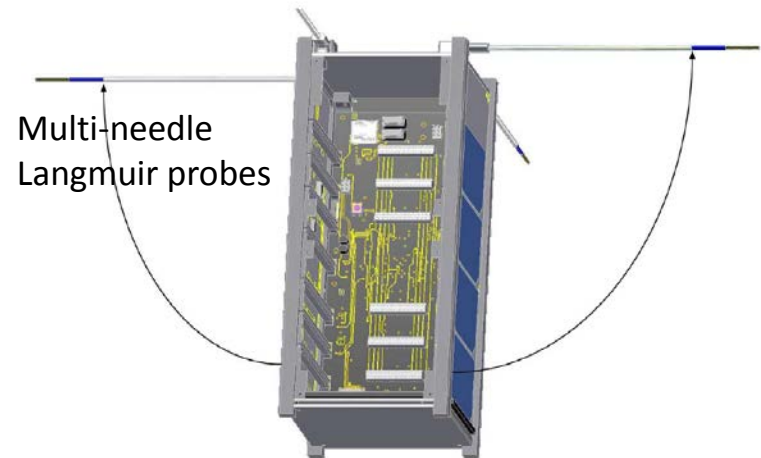
- Flux- $\Phi$ -Probe Experiment (FIPEX)
- 2 corner cube laser retroreflectors (CCR)\*
- Thermistors/thermocouples/RTD (TH)

## Set 3

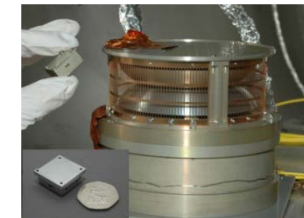
- A set of 4 Langmuir probes (MNLN)
- 2 corner cube laser retroreflectors (CCR)\*
- Thermistors/thermocouples/RTD (TH)

\* Offered as an option

**Detailed info will be given by D. Kataria**



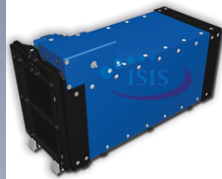
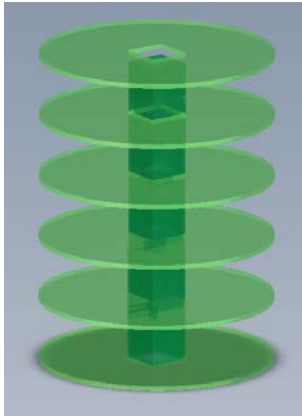
Schematic of the principle of working of the INMS



Miniaturised charged particle analyser along with the Improved Plasma Analyser



# In-Orbit Demonstration



A modular deployment system for double and triple CubeSats

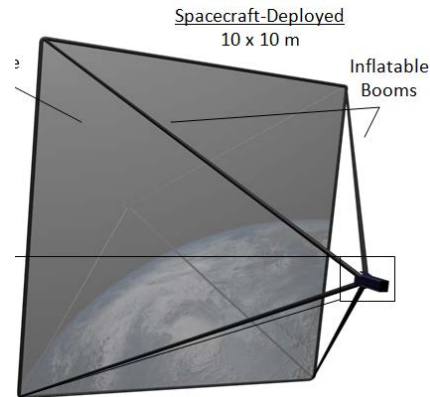
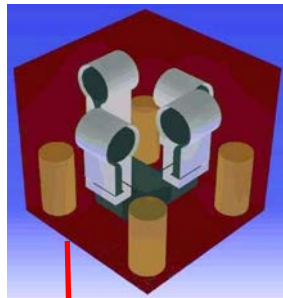


VKI's Re-Entry CubeSat  
QARMAN

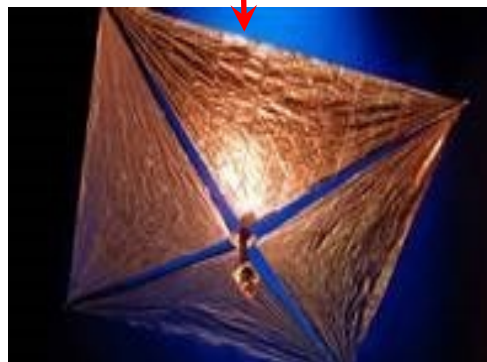
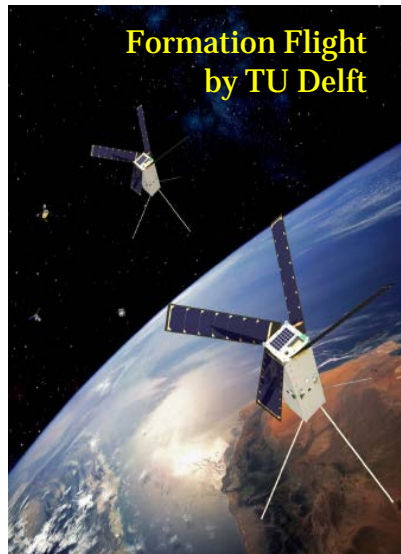
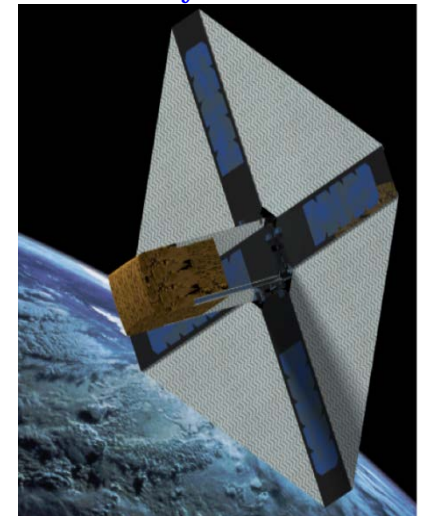
De-orbiting and aerodynamic stability

AeroSDS by VKI

Gossamer-1 Solar Sail demonstration packagem DLR



InflateSail demonstration mission, SSC



## Other In-Orbit Demos:

- End of life analysis, Debris
- Micro-propulsion systems
- Micro-g experiment

# Status of QB50 Project



- Started working on the Project as of Nov 2011
- Kick-off was held at 22 Nov 2011
  
- The Call for Proposals issued on the QB50 web site
- More than 70 proposals were received
- Major technical work accomplished on
  - Orbital dynamics
  - Sensitivity analysis on interaction with the atmosphere
  - Deployment strategy
  - Deployment system
  - Science payload design



- More than 70 proposals received
- Selection of the 50 CubeSats
  - about 40 double CubeSats for atmospheric research to be selected from 50 proposals,
  - about 10 double and triple In-Orbit-Demonstration CubeSats to be selected from 20 proposals, 4 of them already pre-selected (Delta, Phi, QARMAN, Inflatesail)
- Draft Contractual Agreement between the QB50 Consortium and the proposing universities

(this includes the payment of a contribution to the mission cost of 20-90 k€, depending on CubeSat category)
- Availability of funding and readiness at the PDR are critical issues in the selection process, 30% dropout rate assumed
- The first 50 teams that make a payment (deposit) and pass the PDR will be selected, this will probably be finalised by April-May2013
- There will be backup CubeSat teams as well

# Proposed standard inputs for QB50



- Sensitivity analysis on atmospheric models and input parameters are performed. DSMC simulations to study the aerodynamic environment are initiated. Parallel work with ODWG and QB50 partner ITAM
- **T. Scholz, A. L. Aruliah and C. O. Asma, “Recommended set of models and input parameters for the simulations of orbital dynamics of the QB50 CubeSats,” in 5th ICATT, Noordwijk, The Netherlands, 2012**
- proposed atmospheric, solar activity, gravity and other relevant models for the QB50 CubeSat community

## RECOMMENDED SET OF MODELS AND INPUT PARAMETERS FOR THE SIMULATIONS OF ORBITAL DYNAMICS OF THE QB50 CUBESATS

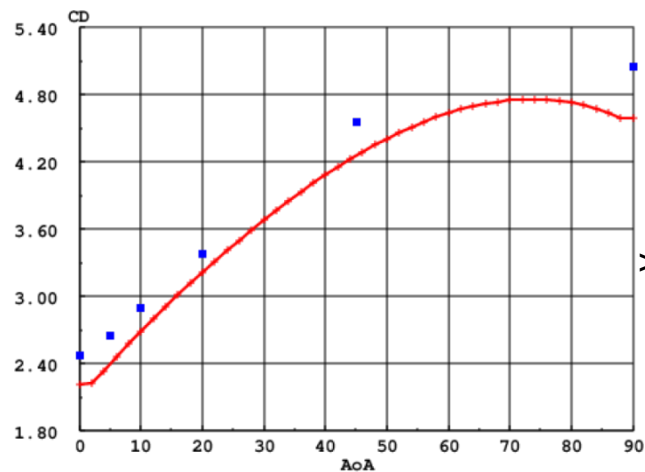
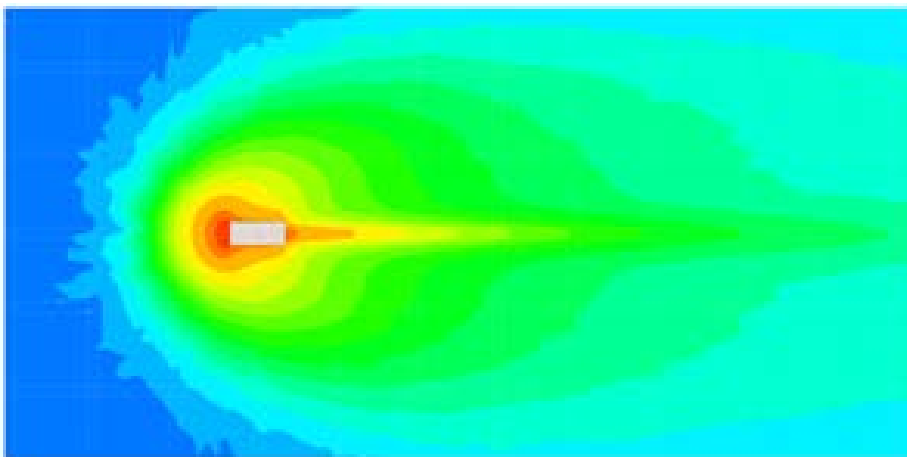
T. Scholz<sup>1a</sup>, C.O. Asma<sup>1b</sup>, and A. Aruliah<sup>2</sup>

<sup>1</sup>*Aeronautics and Aerospace Department, von Karman Institute for Fluid Dynamics, Waterloosesteenweg 72, 1640  
Sint-Genesius-Rode, Belgium, Email: scholz@vki.ac.be <sup>a</sup>, asma@vki.ac.be <sup>b</sup>*

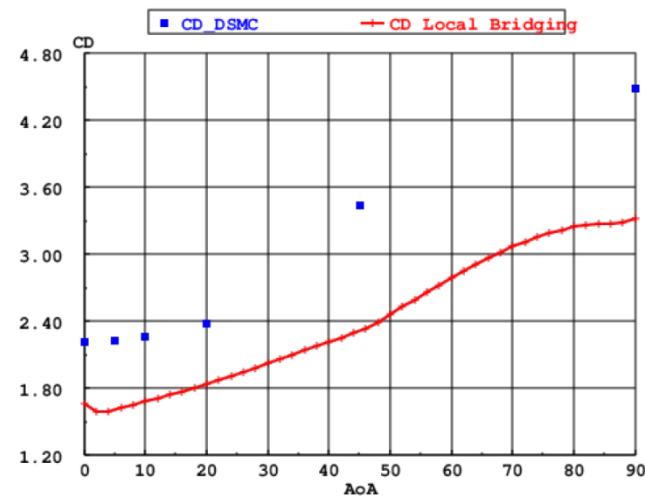
<sup>2</sup>*Department of Physics & Astronomy, University College London, London WC1E 6BT, England, Email:  
a.aruliah@ucl.ac.uk*

# DSMC simulations for CubeSat – Atmosphere interaction

Preliminary computations for selected amount of points of re-entry trajectory were performed and aerothermodynamic characteristics of CubeSat were obtained in free-molecular, transitional, and near-continuum flow regimes and accuracy of the engineering methods was assessed by comparison with the results obtained by the DSMC SMILE code (ITAM & VKI)



> 100 km



< 80 km

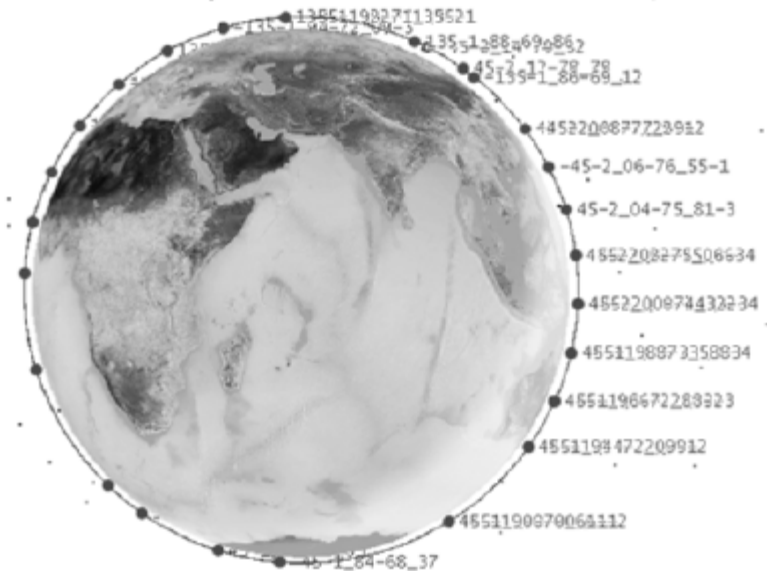


# Deployment Strategy

- How to deploy the 50 CubeSats with minimal collision risk and optimised distribution ?
- Detailed analysis covering ballistic coefficient, deployment direction, deployment frequency
- Best scenario to minimize risk in the first 8 hours, and to optimise a uniform network distribution – the developed strategy can be used directly with the ballistic coefficient database of the selected CubeSats.



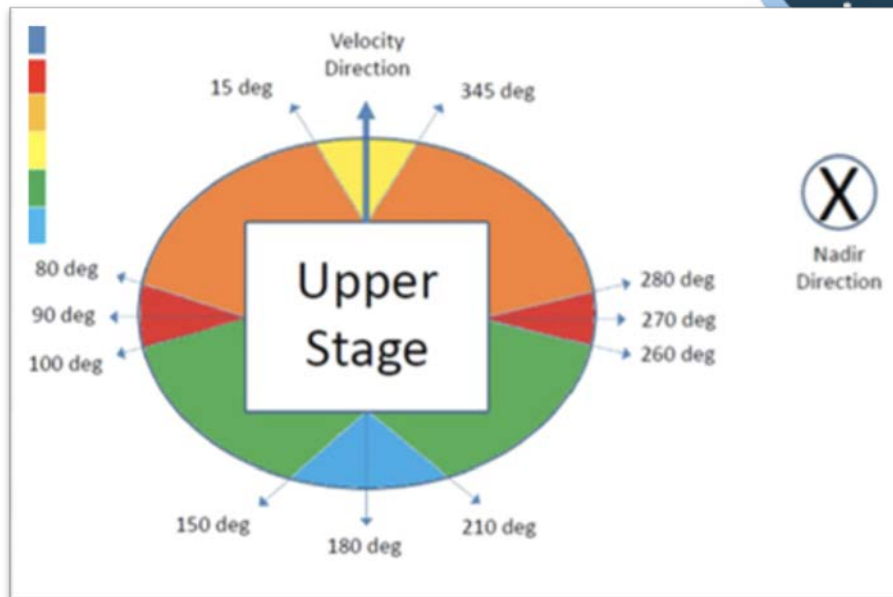
After 20 days



After 30 days

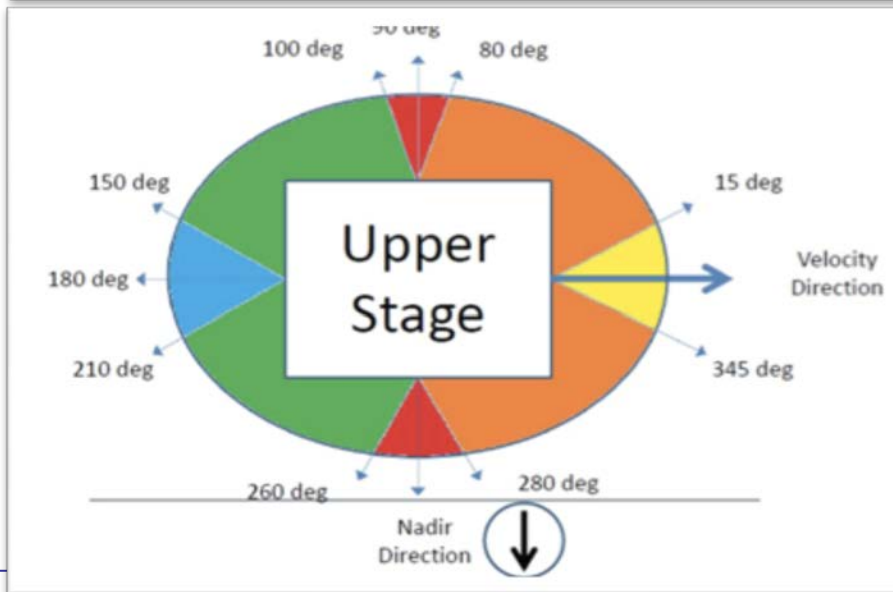
# Deployment Strategy

Top View

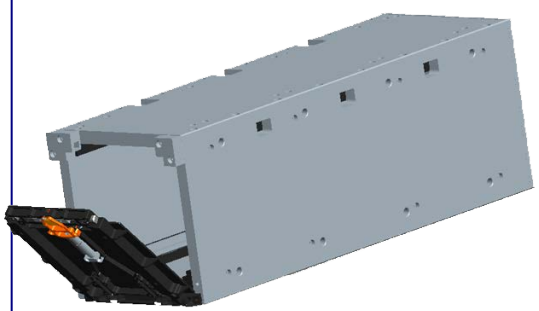


Risk Colors	
High	Red
High-Medium	Orange
Medium	Yellow
Medium-Low	Green
Low	Blue

Side View



# Deployment System



**Concept De-risk  
Prototype  
Prototype**



**Precursor  
Flight  
QuadPack**



**QB50  
StackPack**





# QB50 & EC/REA



- QB50 Project is funded by the European Union's 7<sup>th</sup> Framework Programme (FP7) and is therefore strictly controlled by the Research Executive Agency (REA) of the European Commission (EC).
- All deliverables of the QB50 Project are submitted to EC/REA for approval and acceptance. Besides continuous communication with the EC/REA Project Officer, monthly progress meetings are held.
- QB50 Project has been reviewed in May 2012 (6-monthly progress review meeting) and in Dec 2012 (12-monthly progress review meeting). Following these reviews supported by independent experts, the QB50 Project is given the green light to go ahead with valuable feedback for better progress.
- Currently, the QB50 Project is waiting for the approval by EC/REA for the selection of the Launch Vehicle.

# QB50 Project Main Objective



Facilitating access to space for small scale research missions

“Demonstrate the possibility of launching a network of 50 double CubeSats built by university teams all over the world **as a primary payload** on a low-cost launch **vehicle** to perform first-class science in the largely unexplored lower thermosphere.”

“The project will demonstrate the sustained availability of a low-cost launch **vehicle, the Shtil2.1**, for launching small payloads into low-Earth orbit”

# Unavailability of Shtil2.1 Launch Vehicle

- Proposal largely built around the LV availability
  - Dedicated Launch
  - Low-cost
  - 50 satellites in 1 launch
  - Sustained access to Launch
  - Preferred commonality for precursor flight and final QB50 flight
- Aspects of considering alternatives
  - Dedicated launches are not really available
  - Secondary or Tertiary options to be considered as well
  - Timing and Cost constraints driving the selection
  - Separation of pre-cursor and QB50 launcher type

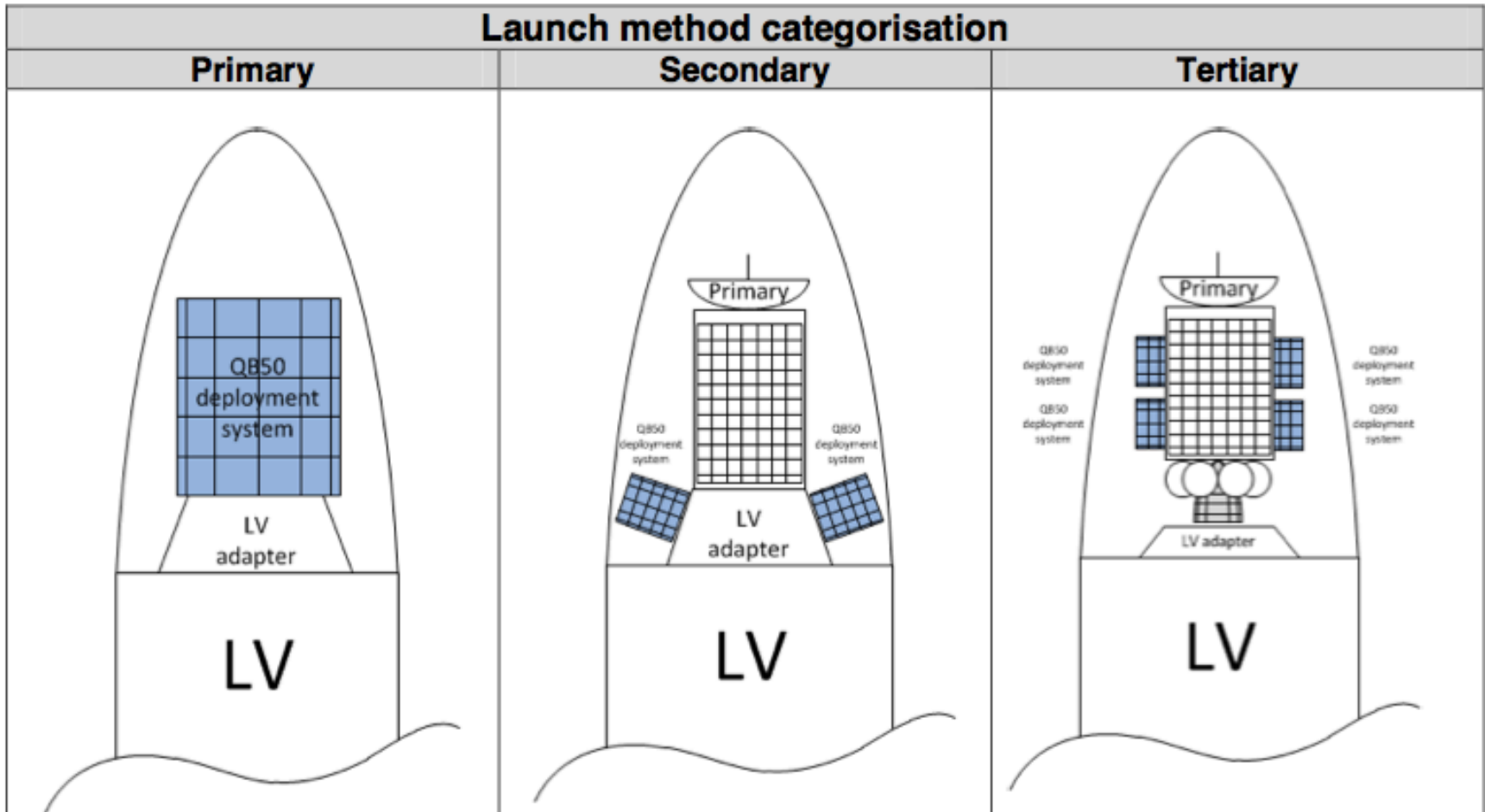
often conflicting



- **Assessment performed by ISIS & VKI in the past 6 months**
  - Various Launch Vehicles considered (18)
  - Accommodation studies performed
  - Costing exercises performed
  - Technical and programmatic discussions ongoing with various providers
  - Constraints:
    - Budget (precursor and main launch less than 3.5M)
    - Timing (Q2-Q3 2015)
    - Orbit (circular at high incidence  $>70^{\circ}$ , minimum 320 km altitude)
    - Technical aspects (loads, payload mass and volume)
    - In-line with the original objectives, repeatable launch
- **Several candidates available for both QB50 flight and precursor flight.**



# Launch method



# QB50 flight options



Launch Vehicle	Mass	Orbit	Price	Risk	Comment
Tsyklon4	OK	OK	OK	Medium	Maiden flight from Brazil Launch Pad, rocket is ready
Verta *	OK	OK	???	Medium	<b>ADM-Aeolus (5th flight)</b>
EuRockot	OK	OK	OK - TBC	Med/Low	BreezeM upper stage, need to go as contractual tertiary
MLV	OK	OK	OK	High	New rocket, China & restrictions

Launchers considered but not ready in time:

- S3 Launch System (Switzerland)
- VLM (Brazil)
- Angara (Russia)
- Other airlaunched vehicles (US/Russia/Japan)

\*) To be investigated whether the EC / REA can assist



# Contractual Agreement



- A Contractual Agreement is to be signed between VKI and the participating CubeSat teams.
- A draft Contract is sent to the CubeSat teams and feedback is received.
- The Contract will have two Annexes:
  - Requirements and Interface Control Document (ready)
  - Launch Contract (will need time)
- All CubeSats will be registered in Belgium and frequency allocations will be made by the Belgian authorities
- The contract will be finalised in Feb 2013 and all CubeSat teams are expected to sign it in Mar-Apr 2013.

# ACKNOWLEDGEMENT



The QB50 Project, the Fifth QB50 Workshop and all related activities are supported by the European Community Framework Programme 7, Grant Agreement no. 284427